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UPPER DEVONIAN (FRASNIAN) CONODONTS AND OSTRACODES FROM THE SUBSURFACE OF WESTERN WEST VIRGINIA

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ABSTRACT—Twenty-eight conodont form species and twenty-one ostracode taxa have been recovered from shales overlying the Onondaga Limestone (Middle Devonian) in a Lincoln County, West Virginia core. Correlations have been established between New York Upper Devonian formations and these subsurface shales on the basis of conodonts. Shales in the core range from the Late Devonian (Frasnian) *Polygnathus asymmetricus* Zone to the Lower *Palmatolepis triangularis* Zone and correlate with the West Falls and Java formations of New York. Ostracodes recovered from the shales include, in addition to the characteristic Late Devonian palaeocopid and podocopid taxa, four entomozoan species: *Bertillonella subcircularis*, *Entomozoe prolifica*, *Richterina symmetrica* and *Ungerella novocosta*. These four species are also reported from the upper Olentangy Shale of central Ohio, and this constitutes the first common occurrence of this group in eastern North America. Several of the entomozoans display close affinities with Frasnian species from France and Belgium.

The early Late Devonian (Frasnian) age determination of the shales indicates the bentonite found in the core at 1,223.6 m (4,014.3 ft) is not the Tioga Bentonite, a Middle Devonian marker bed, but might be coeval with the Belpre (Center Hill?) Bentonite of Ohio.

INTRODUCTION

PREVIOUSLY unreported conodonts and ostracodes have been obtained from the subsurface Devonian shale of the Appalachian Basin in western West Virginia. The single core studied was recovered from Columbia Gas Transmission Corporation (CGTC) well #20403, 7.2 km (4.5 mi) south of latitude 38°10'N and 5.0 km (3.1 mi) west of longitude 82°10'W, Laurel Hill District, Lincoln County, West Virginia (Text-fig. 1). Faunal analysis of this core was undertaken as part of the Eastern Gas Shales Project (EGSP), sponsored by the Department of Energy, in an effort to solve correlation problems encountered during subsurface stratigraphic studies. In particular, microfossils were obtained from the core to correlate the shales with the standard world-wide conodont zonation of Ziegler (1971) and with Devonian formations in New York and Ohio. Paleontologically derived age determinations were also needed to date the bentonite found in the core at 1,223.6 m (4,014.3 ft) because there was serious question as to whether it was

the Tioga Bentonite, a Middle Devonian marker bed, or an Upper Devonian bentonite.

All figured specimens are on deposit in the collections of the West Virginia Geological and Economic Survey (WVGS).

METHODS

Sample collection.—Sixty 1-kilogram (2.2 lb) samples were taken from the interval 1,114.5 m (3,656.5 ft) to 1,234.7 m (4,051.0 ft) below the top of the well. All depths in the text and figures are corrected log depths, not drillers' or core depths; original log depths are in feet. Because the core had previously been sampled for other purposes it was not possible to obtain samples at specific or regular intervals. Therefore, each sample is composed of pieces of shale taken throughout each box of core; each box contained approximately 2.1 m (7.0 ft) of core. Some attempt was made to take material from the top, middle and bottom of the core section in each box, thereby making each collection more or less a channel sample. In addition, three samples were obtained from the uppermost 0.9 m (3.0 ft) of Onondaga Limestone.

Sample preparation.—Onondaga Limestone samples were disaggregated with standard acetic acid procedures. Disaggregation of shale

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samples was accomplished by using a two-step bleaching and boiling process developed for this study (Duffield and Warshauer, 1979). Conodonts and pyritized ostracodes were concentrated by the use of heavy liquid separations, and calcareous ostracodes and associated fossils were picked from the light fractions.

LITHOSTRATIGRAPHY

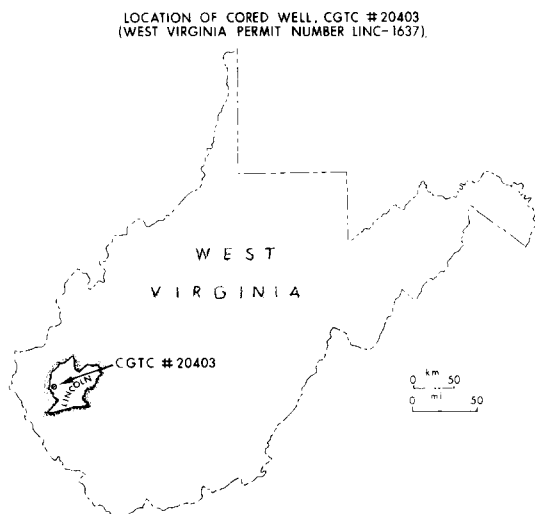
Lithology.—The Lincoln County CGTC #20403 core was described by Byrer and others (1976). The study interval consists of light green-gray shales alternating with medium- and dark-gray shales. Medium and greenish gray shales are more prominent in the upper half of the interval; in the lower half of the section medium- and dark-gray shales predominate.

Six petrographic rock types have been described in the core (Nuhfer and Vinopal, 1978). The four shale types consist of: 1) finely laminated; 2) banded; 3) nonbanded; and 4) combinations of the above types. Finely laminated dark shales are the dominant rock type at the base of the core, the interval considered in this study.

Clay-size material is largely illite and quartz with some chlorite; dolomite and calcite are common minor minerals in the shales (Laresse and Heald, 1977) and are abundant as cementing agents in the siltstones (Nuhfer and Vinopal, 1978). Pyrite occurs as framboids, aggregates of framboids, euhedral, octahedral and, more rarely, cubic crystals.

Stratigraphic framework.—Text-figure 2 compares the Middle and Upper Devonian stratigraphy of West Virginia, New York and Ohio. The Onondaga Limestone is the lowermost Middle Devonian formation in West Virginia and New York. In eastern West Virginia the Huntersville Chert and Needmore Shale are facies equivalents of the Onondaga. In Ohio the Columbus Limestone has been correlated with the upper part of the Onondaga. Overlying the Onondaga in places throughout the Appalachian Basin is the Tioga Bentonite, a Middle Devonian marker bed. The middle coarse zone of the Tioga has been used to identify the top of the Onesquethaw Stage (Denison and Textoris, 1977).

In the subsurface in western West Virginia the term "Devonian shales" refers to the shale



TEXT-FIG. 1—Location of cored well, CGTC #20403, Lincoln County, West Virginia.

sequence from the top of the Onondaga Limestone to the Lower Mississippian Berea Sandstone (Patchen, 1977). In outcrop in Ohio, West Virginia and New York, Middle and Upper Devonian formations have been divided as shown in Text-fig. 2. Correlation of subsurface shales with outcrop formations or their facies equivalents is currently being undertaken by EGSP stratigraphers, and tentative correlations based on geophysical and faunal evidence are summarized in Text-fig. 2.

FAUNA OF THE LINCOLN COUNTY CGTC #20403 CORE

Conodonts.—From approximately 250 specimens, 28 form species representing 12 form genera have been identified in the samples from the study section of the Lincoln County CGTC #20403 core. The relative scarcity of bar (ramiform) conodonts, in particular species of *Hindeodella*, probably reflects lack of preservation rather than paucity in the conodont apparatuses; bar fragments were found in nearly every sample but were not identifiable. The conodonts found in this study are listed below and illustrated in Plates 1 and 2.

Ancyrodella nodosa Ulrich and Bassler, 1926

A. spp.

Ancyrognathus asymmetricus (Ulrich and Bassler, 1926)

DEVONIAN	UPPER	EUROPEAN SERIES	NORTH AMERICAN STANDARD		OHIO			NEW YORK		WEST VIRGINIA SUBSURFACE		WEST VIRGINIA OUTCROP	
		SERIES	STAGE										
		FAMENNIAN	CHAUTAUQUAN	CASSADAGA	OHIO SHALE	CANADAWAY GROUP		OHIO SHALE	CHEMUNG FORMATION				
		FRASNIAN	SENECAN	COHOCTON	UPPER OLENTANGY SHALE			JAVA FORMATION		BRALLIER FORMATION	BRALLIER FORMATION		
	WEST FALLS GROUP							ANGOLA SHALE MEMBER	RHINESTREET SHALE MEMBER				
	FINGER LAKES			SONYEA FORMATION		?	?						
	MIDDLE	GIVETIAN	ERIAN	TAGHANIC	?	?	?	GENESEE FORMATION	UNCONFORMITY(?)	?	?	?	
				TIOUGHNIOGA				TULLY LIMESTONE			?	?	
				CAZENOVIA				MOSCOW FORMATION			MARCELLUS FORMATION	MARCELLUS FORMATION (?)	MARCELLUS FORMATION
								LUDLOWVILLE FORMATION					
SKANEATELES FORMATION													
?				LOWER OLENTANGY SHALE				ONONDAGA LIMESTONE			?	?	ONONDAGA LIMESTONE
DELAWARE LIMESTONE				ONONDAGA LIMESTONE				?			?	ONONDAGA LIMESTONE	
EIFELIAN	ULSTERIAN	ONESQUETHAW	COLUMBUS LIMESTONE	ONONDAGA LIMESTONE	ONONDAGA LIMESTONE								

TEXT-FIG. 2—Stratigraphic relationship of Middle and Upper Devonian rocks in Ohio, New York and West Virginia (modified from Oliver and others, 1969; West Virginia subsurface from J. F. Schwietering, pers. commun.).

A. spp.

Bryantodus dignatus Stauffer, 1938

B. aff. *B. stratfordensis* Stauffer, 1938

B. aff. *B. typicus* Bassler, 1925

B. sp. A

B. sp. B

Hindeodella sp. indet.

Icriodus symmetricus Branson and Mehl, 1938

Ligonodina? aff. *L. panderi* (Hinde, 1879)

L.? sp. indet.

Nothognathella aff. *N. bicristata* Youngquist and Miller, 1948

Ozarkodina immersa (Hinde, 1879)

Palmatodella? aff. *P. delicatula* Bassler, 1925

Palmatolepis gigas Miller and Youngquist, 1947

P. aff. *P. hassi* Müller and Müller, 1957

P. aff. *P. proversa* Ziegler, 1958

EXPLANATION OF PLATE 1

SEM photomicrographs; all specimens $\times 40$. Color alteration index (CAI) is $1\frac{1}{2}$ –2.

FIG. 1—*Ancyrognathus asymmetricus* (Ulrich and Bassler). Upper view of WVGS 410002, from sample 9.

2—*Ancyrodella nodosa* Ulrich and Bassler. Upper view of WVGS 410001, from sample 11.

3—*Palmatolepis triangularis* Sannemann. Upper view of WVGS 410021, from sample 2.

4—*Palmatolepis gigas* Miller and Youngquist. Upper view of WVGS 410015, from sample 14.

5—*Palmatolepis* aff. *P. hassi* Müller and Müller. Upper view of WVGS 410016, from sample 39.

6—*Palmatolepis* aff. *P. tenuipunctata* Sannemann. Upper view of WVGS 410020, from sample 4.

7—*Palmatolepis punctata* (Hinde). Upper view of WVGS 410018, from sample 2.

8—*Palmatolepis subrecta* Miller and Youngquist. Upper view of WVGS 410019, from sample 14.

9—*Palmatolepis* sp. A. Upper view of WVGS 410022, from sample 16.



- 10—*Palmatolepis* aff. *P. proversa* Ziegler. Upper view of WVGs 410017, from sample 50.
 11—*Icriodus symmetricus* Branson and Mehl. Upper view of WVGs 410009, from sample 19.
 12—*Polygnathus* aff. *P. asymmetricus ovalis* Ziegler and Klapper. Upper view of WVGs 410023, from sample 37.
 13—*Polygnathus decorosus* Stauffer. Upper view of WVGs 410024, from sample 3.
 14—*Polygnathus dubius* Hinde. Oblique lateral view of WVGs 410025, from sample 6.
 15—*Polygnathus webbi* Stauffer. Oblique lateral view of WVGs 410026, from sample 27.



EXPLANATION OF PLATE 2

SEM photomicrographs; all specimens $\times 40$. Color alteration index (CAI) is $1\frac{1}{2}$ –2.

FIG. 1—*Bryantodus* sp. A. Lateral view of WVGS 410006, from sample 10.

2—*Bryantodus* sp. B. Lateral view of WVGS 410007, from sample 7.

3—*Bryantodus* aff. *B. typicus* Bassler. Lateral view of WVGS 410005, from sample 10.

- P. punctata* (Hinde, 1879)
P. subrecta Miller and Youngquist, 1947
P. aff. P. tenuipunctata Sannemann, 1955
P. triangularis Sannemann, 1955
P. sp. A
P. spp.
Polygnathus aff. P. asymmetricus ovalis
 Ziegler and Klapper, 1964
P. decorosus Stauffer 1938
P. dubius Hinde, 1879
P. webbi Stauffer, 1938
Synprioniodina aff. S. bicurvata Branson
 and Mehl, 1933
S. sp. A
S. sp. B
S. sp. C
 Genus indet.
Ostracodes.—Approximately 840 specimens
 were recovered from the 37 ostracode-bearing
 samples (remaining samples were barren of
 ostracodes). All of the identifiable specimens
 could be subdivided into 19 generic level cat-
 egories with 11 of the taxa being sufficiently
 well preserved for specific assignment. Unfor-
 tunately, crushing, coarse recrystallization
 and pyritization rendered many of the speci-
 mens unidentifiable. The following taxa, illus-
 trated in Plate 3, were found.
Amphissites carmani Stewart and Hendrix,
 1945
A. shafferi Stewart and Hendrix, 1945
Bairdia? sp.
Bertillonella subcircularis Stewart and
 Hendrix, 1945
Bythocyproidea sp.
Coelonella punctulifera Stewart and Hen-
 drix, 1945
C. sp.
Cytherellina sp.
Entomozoe prolifica (Stewart and Hendrix,
 1945)
Eriella robusta Stewart and Hendrix, 1945
Kirkbyella sp.
Quasillites sp.
Richterina symmetrica Stewart and Hen-
 drix, 1945
Ropolonellus sp.
Sansabella? curiosa
*Senescella (Plagionephrodes) crassimargin-
 ata* Stewart and Hendrix, 1945
Thrallella mimica Stewart and Hendrix,
 1945
Ulrichia sp.
Ungerella novecosta (Stewart and Hendrix,
 1945)
 Ostracode indet. A
 Ostracode indet. B
Associated fauna.—Additional fossils in-
 clude abundant foraminifera and *Styliolina*.
 In a few samples pyritized micromorph bra-
 chiopods, gastropods and cephalopods were
 present.

CONODONT ZONATION

Ziegler (1971) reviewed the investigations
 that led to the development of a standard De-

←

- 4—*Bryantodus dignatus* Stauffer. Lateral view of WVGS 410003, from sample 53.
 5—*Ozarkodina immersa* (Hinde). Lateral view of WVGS 410013, from sample 4.
 6—*Palmatodella?* aff. *P. delicatula* Bassler. Lateral view of WVGS 410014, from sample 5.
 7—*Bryantodus* aff. *B. stratfordensis* Stauffer. Lateral view of WVGS 410004, from sample 11.
 8—*Nothognathella* aff. *N. bicristata* Youngquist and Miller. Lateral view of WVGS 410012, from
 sample 3.
 9—*Hindeodella* sp. indet. Lateral view of WVGS 410008, from sample 5.
 10—Genus indet. A. Lateral view of WVGS 410030, from sample 54.
 11—*Ligonodina?* aff. *L. panderi* (Hinde). Lateral view of WVGS 410010, from sample 13.
 12—Genus indet. B. Lateral view of WVGS 410031, from sample 28.
 13—Genus indet. C. Lateral view of WVGS 410032, from sample 17.
 14—*Ligonodina?* sp. indet. Lateral view of WVGS 410011, from sample 11.
 15—Genus indet. D. Lateral view of WVGS 410033, from sample 19.
 16—*Synprioniodina* sp. A. Lateral view of WVGS 410028, from sample 10.
 17—*Synprioniodina* sp. B. Lateral view of WVGS 410029, from sample 3.
 18—*Synprioniodina* sp. C. Lateral view of WVGS 410034, from sample 4.
 19—*Synprioniodina* aff. *S. bicurvata* (Branson and Mehl). Lateral view of WVGS 410027, from sample
 34.



vonian conodont zonation in Europe (Text-fig. 3). Since 1971 some revisions of Devonian conodont zones have been made, specifically in the Middle/Upper Devonian boundary beds (Ziegler and others, 1976), but the Upper Devonian zonation remains relatively unchanged and has been successfully applied in intercontinental correlations.

Conodonts from the Onondaga Limestone samples of the core were given an age assignment of lowermost Middle Devonian (lower Eifelian) by A. G. Harris (1977, written commun.). This age determination is based on the joint occurrence of *Icriodus corniger* Wittekindt and *Polygnathus costatus* Klapper.

In general, the diagnostic conodonts of the shales overlying the Onondaga (Text-fig. 4; Pl. 1) indicate an early Late Devonian age. This

age determination is based primarily on the occurrence of species of *Palmatolepis* as well as other typically early Late Devonian species such as *Polygnathus decorosus*, *Polygnathus webbi* and *Icriodus symmetricus*. *Polygnathus dubius*, which is present in the Lincoln County core fauna, is reported to be restricted to the Middle/Upper Devonian boundary beds (Klapper, 1973) but according to Huddle (1970) it ranges into the Upper Devonian formations of New York. The section from the top of the Onondaga to 1.86 m (6.1 ft) above the Onondaga remains of uncertain age because no conodonts were found in this interval.

Index species of conodonts from the core show that shales of the studied interval range from possibly the *Polygnathus asymmetricus*

EXPLANATION OF PLATE 3

SEM photomicrographs; all specimens $\times 50$

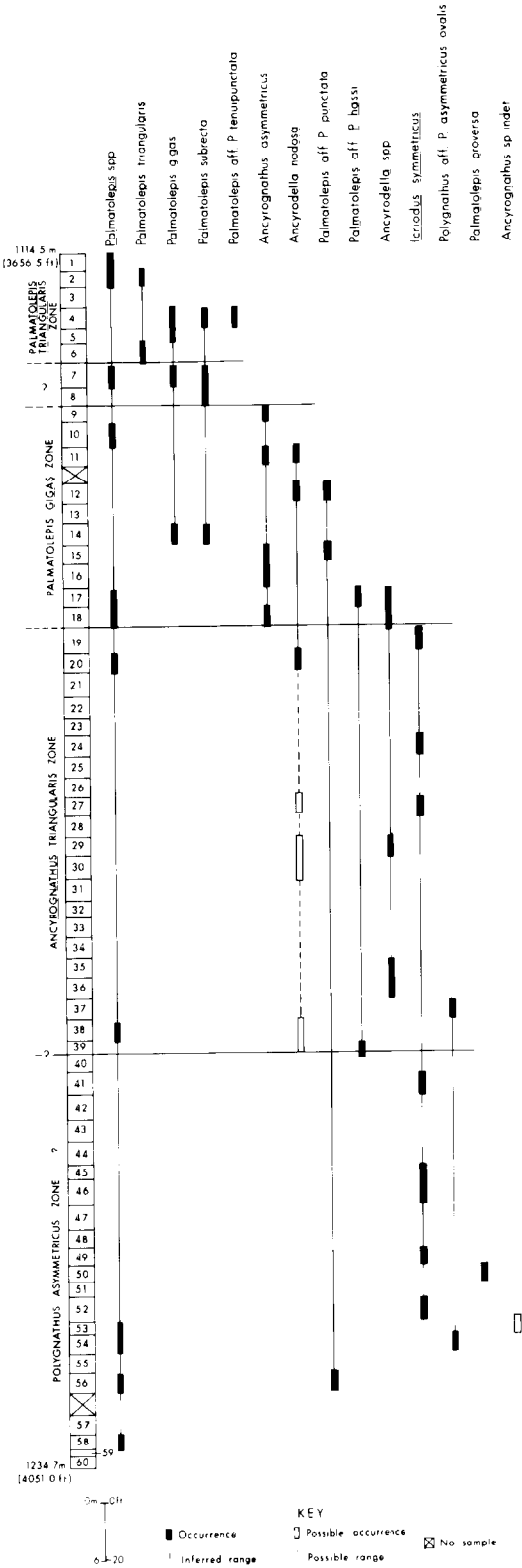
- FIG. 1—*Eriella robusta* Stewart and Hendrix. Lateral view of WVGs 410044, from sample 17.
 2—*Coelonella punctilifera* Stewart and Hendrix. Lateral view of WVGs 410041, from sample 16.
 3—*Quasillites* sp. Oblique ventral lateral view of a carapace left valve. Note both the posterior reticulation and low posteroventral node visible, due to the high tilt angle, on the opposite valve. WVGs 410047, from sample 18.
 4—*Cytherellina* sp. Lateral view of a left valve. WVGs 410043, from sample 18.
 5—*Ropolonellus* sp. Lateral view of a broken left valve. WVGs 410049, from sample 11.
 6—*Coelonella* sp. Lateral view of a carapace. Note the posterior spine and fine reticulation over entire lateral surface. WVGs 410042, from sample 35.
 7—*Amphissites shafferi* Stewart and Hendrix. Lateral view of a carapace. WVGs 410035, from sample 13.
 8—*Amphissites carmeni* Stewart and Hendrix. Lateral view of a carapace. WVGs 410035, from sample 13.
 9—*Ulrichia* sp. Lateral view of a coarsely recrystallized carapace. WVGs 410053, from sample 14.
 10—*Thrallella mimica* Stewart and Hendrix. Lateral view of a carapace. Notice the posterior ridge and associated pre-ridge pits. WVGs 410052, from sample 16.
 11—*Kirkbyella* sp. Lateral view of a poorly preserved carapace. WVGs 410046, from sample 14.
 12—*Sansabella? curiosa* Stewart and Hendrix. Lateral view of a partially exfoliated carapace. WVGs 410050, from sample 9.
 13—*Senescella (Plagionephrodes) crassimarginata* Stewart and Hendrix. Lateral view of a carapace. WVGs 410051, from sample 16.
 14—*Bythocyproidea* sp. Lateral view of a carapace. WVGs 410040, from sample 34.
 15—Ostracode indet. B. Lateral view of a carapace. WVGs 410056, from sample 29.
 16—Ostracode indet. A. Lateral view of a carapace. WVGs 410055, from sample 16.
 17—*Entomozoe prolifica* Stewart and Hendrix. Lateral view of a partially crushed carapace. WVGs 410044, from sample 42.
 18—*Bairdia?* sp. Lateral view of a right valve. WVGs 410037, from sample 2.
 19, 22—*Bertillonella subcircularis* Stewart and Hendrix. 19, lateral view of a completely flattened carapace. WVGs 410038, from sample 42. 22, lateral view of an inflated carapace. WVGs 410039, from sample 21.
 20—*Ungerella novecosta* Stewart and Hendrix. Lateral view of a crushed carapace. WVGs 410054, from sample 42.
 21—*Richterina symmetrica* Stewart and Hendrix. Lateral view of an inflated heavily pyritized carapace. WVGs 410048, from sample 22.

CONODONT ZONE		EUROPEAN SERIES	NORTH AMERICAN STANDARD				
			SERIES	STAGE			
<u>PALMATOLEPIS CREPIDA</u>		FAMENNIAN	CHAUTAUQUAN	CASSADAGA			
<u>PALMATOLEPIS TRIANGULARIS</u>	UPPER			COHOCTON			
	MIDDLE						
	LOWER						
<u>PALMATOLEPIS GIGAS</u>	UPPER-MOST				FRASNIAN	SENECAN	
	UPPER						
	MIDDLE						
LOWER							
<u>ANCYROGNATHUS TRIANGULARIS</u>							
<u>POLYGNATHUS ASYMMETRICUS</u>		UPPER					
		MIDDLE					
		LOWER					
		LOWER-MOST					
<u>SCHMIDTOGNATHUS HERMANNI-POLYGNATHUS CRISTATUS</u>				FINGER LAKES			
<u>POLYGNATHUS VARCUS</u>				TACHANIC			
<u>ICRIODUS OBLIQUIMARGINATUS</u>	UPPER	GIVETIAN	ERIAN	TIUGHNIOGA			
	LOWER			CAZENOVIA			
<u>POLYGNATHUS KOCKELIANUS</u>		EIFELIAN	ULSTERIAN	ONESQUETHAW			
<u>OZARKODINA BIDENTATA</u>							
<u>ICRIODUS CORNIGER</u>							

TEXT-FIG. 3—Standard Devonian conodont zonation (modified from Ziegler, 1971).

Zone into the Lower *Palmatolepis triangularis* Zone. Within this interval, zone boundaries are not sharply delineated. Because each sample contains 2.1 m (7.0 ft) of core, depths cited below do not indicate precise boundaries of each zone.

Polygnathus asymmetricus Zone.—The *P. asymmetricus* Zone cannot be established in the Lincoln County core. Two specimens which have affinities to *P. asymmetricus* oval-



TEXT-FIG. 4—Distribution of biostratigraphically significant conodont species in core CGTC #20403, Lincoln County, West Virginia.

is occur in the section from 1,186.6 m (3,893.0 ft) to 1,223.2 m (4,013.2 ft). However these specimens occur with fragments of *Ancyrognathus* at 1,221.3 m (4,007.0 ft) and possibly with *Ancyrodella nodosa* at 1,193.8 m (3,916.5 ft); the lower limit for these taxa is the *Ancyrognathus triangularis* Zone. Thus, the specimens of *Polygnathus asymmetricus ovalis* are probably reworked.

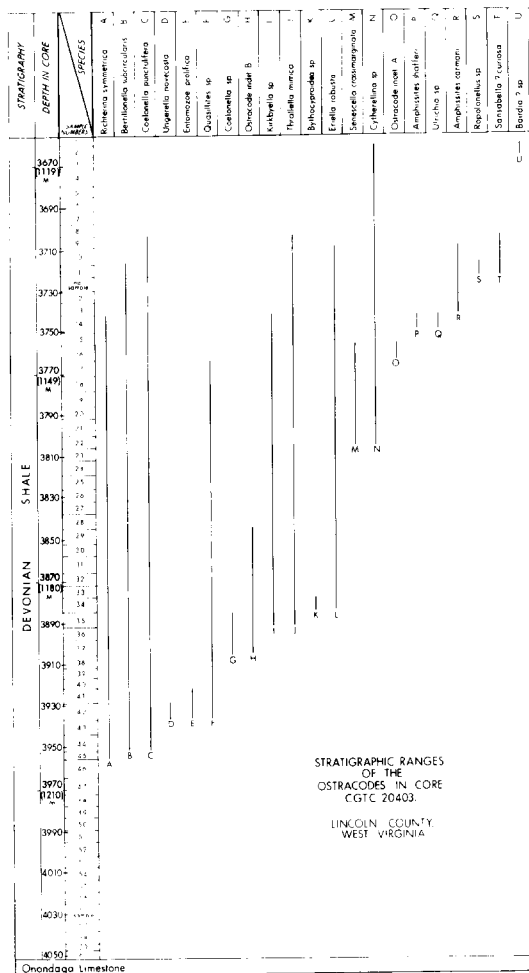
Ancyrognathus triangularis Zone.—Conodonts that could be representative of the *A. triangularis* Zone first occur at 1,221.3 m (4,007.0 ft) (fragments of *Ancyrognathus*). Other conodonts within the interval 1,221.3 m (4,007.0 ft) to 1,143.2 m (3,750.6 ft) include *Polygnathus decorosus* and *Ancyrodella nodosa*. Both of these species are reported to range into the *Palmatolepis gigas* Zone. Therefore, the upper limit of the *Ancyrognathus triangularis* Zone can be approximated at 1,151.5 m (3,778.0 ft) at which depth *Ancyrognathus asymmetricus* first appears.

Palmatolepis gigas Zone.—The *P. gigas* Zone is recognized at 1,151.5 m (3,778.0 ft) with the first appearance of *Ancyrognathus asymmetricus*. *P. gigas*, the indicator of this zone, first occurs at 1,143.2 m (3,750.6 ft) and ranges up to 1,119.2 m (3,672.0 ft).

Palmatolepis triangularis Zone.—The lowest occurrence of *P. triangularis* in the Lincoln County core is at 1,125.1 m (3,691.3 ft). *P. triangularis* is restricted to the *P. triangularis* Zone and thus is the highest Devonian conodont zone recognized within the studied interval. One specimen with affinities to *P. tenuipunctata* occurs within this interval; the lower limit for *P. tenuipunctata* is the base of the *P. triangularis* Zone.

OSTRACODE BIOSTRATIGRAPHY

Few studies of Upper Devonian ostracodes have been undertaken in North America (Stewart and Hendrix, 1945b; Gibson, 1955; McGill, 1963; Braun, 1976, 1978; Lethiers, 1978). Hence, intracontinental correlations of this fauna are difficult. However, of the eleven species occurring in these collections, ten of them are known from the upper Olentangy Shale of central Ohio (Stewart and Hendrix, 1945b). The remaining single identifiable species, *Eriella robusta*, is also known from Ohio, but from the Middle Devonian Plum Brook Shale (Stewart and Hendrix, 1945a). Middle Devonian ostracodes in North Ameri-



TEXT-FIG. 5—Stratigraphic ranges of the ostracodes in core CGTC #20403, Lincoln County, West Virginia.

ca, on the other hand, have been studied to a much greater extent and are much better understood (see Tillman and Murphy, 1978, for a fairly complete reference list). The present fauna, with the exception of *E. robusta*, does not correlate with that of any of the published studies on Middle Devonian ostracodes, including the fairly extensive ostracode fauna illustrated by Tillman (1970) from the lower Olentangy of Ohio.

In addition, the occurrence of four entomozoon species (*Bertillonella subcircularis*, *Entomozoe prolifica*, *Richterina symmetrica* and *Ungerella novecosta*) herein constitute the first report of an entomozoon fauna in the Devonian of the Appalachian Basin. Two of the

entomozoans, *B. subcircularis* and *E. prolifica*, are closely related to, if not conspecific with, forms reported from Frasnian beds in France and Belgium (Lethiers, 1970, 1974a, 1974b, 1975). Based on the above observations, we conclude that the ostracodes reported here (Pl. 3; Text-fig. 5) are indicative of a Late Devonian (Frasnian) age. It must be noted that although conodonts are found throughout the core, ostracodes are lacking from the lower 15 samples and could not be used to date this interval.

SUMMARY AND CONCLUSIONS

The age of the shales overlying the Onondaga Limestone in the Lincoln County #20403 core is early Late Devonian (Frasnian), and the age of the top of the Onondaga in the core is early Middle Devonian (Eifelian). Although 1.86 m (6.1 ft) of shale immediately above the Onondaga cannot be dated, the age difference between the Onondaga and the shales indicates that a major unconformity exists between the Middle and Upper Devonian in western West Virginia.

Although upper and lower limits of conodont zones in the Lincoln County core cannot be clearly delineated, correlations with other formations in the Appalachian basin can be made. The shales range from at least the *Ancyrognathus triangularis* Zone to the *Palmatolepis triangularis* Zone; these same zones are found in the West Falls and Java formations of New York (Huddle, 1968; Oliver and others, 1969). The abundance of *Palmatolepis* and the presence of *Ancyrognathus* and *Ancyrodella* in the Lincoln County fauna indicate that this fauna is younger than that of the Columbus and Delaware Limestones as described by Stewart and Sweet (1956) and Ramsey (1969), respectively. The Lincoln County conodont fauna does have some species in common with the fauna of the upper part of the Olentangy Shale as described by Gable (1973).

The ostracode fauna also indicates a Late Devonian age because it closely resembles the fauna described from the upper Olentangy of central Ohio by Stewart and Hendrix (1945b). In addition, this first report of entomozoan ostracodes in the central Appalachians includes several taxa (*Bertillonella subcircularis* and *Entomozoe prolifica*) that display close affinities to species from the Frasnian of Bel-

gium and France (Lethiers, 1970, 1974a, 1974b, 1975).

The early Late Devonian age determination for the shales indicates the bentonite found in the core is not the middle coarse zone of the Tioga Bentonite used as a marker bed for the top of the Middle Devonian Onesquethaw Stage. Collins (1979) has recently demonstrated the existence of an Upper Devonian bentonite in eastern Ohio, the Belpre, that consistently lies above the Tioga in the lower portion of the Black Shale sequence. Due to the close proximity of Lincoln County, West Virginia, to Ohio occurrences of the Belpre, we believe that the bentonite in the core might be correlative with the Belpre. As discussed by Collins (1979) the Belpre is most probably coeval with the Center Hill Bentonite of Tennessee. Correlation of the Lincoln County bentonite with the Center Hill was independently suggested, based on studies of conodonts from Devonian Shale outcrops in Tennessee, by Harris (1978, written commun.).

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